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DEPARTMENT OF GEOLOGY/NASA-GSFC GEOBOTANICAL INVESTIGATION

SUMMARY REPORT

This document reports on work conducted in conjunction with NASA/GSFC in two areas: 1) geobotanical mapping in the southern Appalachians and 2) soil metal-associated changes in vegetation spectral responses in the reflective and emissive portions of the electromagnetic spectrum (EMS). IS STUDIED

One of the objectives of ongoing investigations is to determine whether deciduous forest vegetation reflection and emission characteristics show detectable changes that can be related to residual soil characteristics. Analyses of such related characteristics will enhance THE ~~our~~ ability to discriminate underlying lithologies as well as variances within lithologies associated with natural heavy metal occurrences. A second objective is to develop an understanding of the factors which contribute to the differing spectral signatures of various lithology/soil types. Both objectives will be accomplished through a combination of field data collection and remote spectral analysis.

Background

Thematic Mapper Simulator (TMS) data were acquired over forest study areas in Virginia and West Virginia for both lithologic mapping and soil metal investigations. Data were collected during spring leaf out (May), summer water stress (August) and fall senescence (October). During the summer of 1983-1985 botanical surveys were completed for one hundred

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forest test sites distributed over three major lithologies (sandstone, shale and limestone) in the Appalachian mapping study areas. In the fall of 1984 and during spring, summer and fall of 1985, forest canopy thermal data were collected at the soil geochemical anomaly study sites using a hand-held remote infrared (IR) sensor. Results of the analyses of these data sets are presented separately for the mapping and soil metal-enrichment investigations.

Results and Conclusions--Geobotanical Mapping

Results of the botanical surveys are presented as pie charts illustrating the average community distribution from each lithology (Figure 1). It is apparent that: 1) sandstone communities are characterized by canopies dominated by chestnut oak (*Quercus prinus*), black oak (*Q. velutina*) and northern red oak (*Q. rubra*), 2) shale communities have canopies composed of chestnut oak, white oak (*Q. alba*) and northern red oak, and 3) limestone communities, while highly variable in their species composition, more closely resemble shale than sandstone communities. Field observations and forestry literature suggest that depth of soil and water availability are factors which account for the differences in species distribution over the three lithologies.

TMS data over the three lithologies were compared with Tukey's studentized range test to determine on which dates and in which bands the lithologies had significantly different reflectance. Results of this analysis (summarized in Figures 2

and 3) suggest that TMS band 5 (1000-1350 nm) data acquired during fall leaf senescence (color change) are best for mapping the different lithologies. It was also possible to separate the three lithologies in data collected during the period of summer water stress. In these data limestone sites which were noticeably wetter than nearby shale sites were significantly cooler in the TMS thermal channel (10200-12550 nm).

Results of the TMS data analysis suggest that it is possible to separate lithologies throughout the growing season based on differences in canopy reflectance in the leaf structure/biomass and canopy emission wavebands. This separation can be effected despite the distribution of several species across lithologies suggesting that a more subtle shift in species assemblage rather than presence or absence of a particular species is important in lithologic discrimination in this temperate deciduous forest.

Results and conclusions--Soil metal-anomaly detection

Thermal data collected with the hand-held instrument indicated that there was a more rapid decrease in canopy emission over the control sites in late afternoon (approximately 1600-1800 local time) as compared with trees rooted in soils naturally enriched in copper, lead and zinc. Measurements taken in the summer and fall show a consistently higher temperature for canopies at the metal enriched as compared compared with control canopies in the late afternoon. This suggested that the TMS thermal channel was potentially useful for discriminating forest canopies exhibiting elevated

late afternoon temperatures associated with soil heavy metal-enrichment. This discrimination could made during the portion of the growing season when major phenologic events were not occurring. As such differences in temperature were not found in the spring, there was evidence that water availability to the plant canopy might be interacting with the impact of soil heavy metal enrichment.

Preliminary analyses of the TMS digital data indicate that a significant amount of variation in the thermal channel signal is explained during the summer by soil metal levels. Stepwise discriminant analyses incorporating TMS data collected in the spring, summer and fall reveal that thermal canopy emission data in the spring had the best overall association with soil chemistry. However, a consistent reversal of thermal behavior from the hand-held data was found. Heavy metal-enriched sites appeared relatively cooler. This indicates that vegetation composition and phenologic (ground truth) data are extremely important no matter which portions of the spectrum are monitored and must not be discounted when conducting geologic studies over vegetated areas.

Discussion

While this report covers work on two remote sensing-geologic studies, both studies found the thermal channel to be important in discriminating various vegetation-soil-lithologic interactions. The thermal channel appears to contribute forest canopy information not found in other wavebands monitored. This suggests that design of future land remote sensing instruments should incorporate improvements in signal-to-noise

and spatial resolution in this longer wavelength portion of the EMS.

Understanding changes in forest canopy spectral characteristics which can be related to soil type, including those enriched in heavy metals, and/or shifts in species assemblage will ultimately enhance our ability to discriminate lithologies from which such soils are derived.

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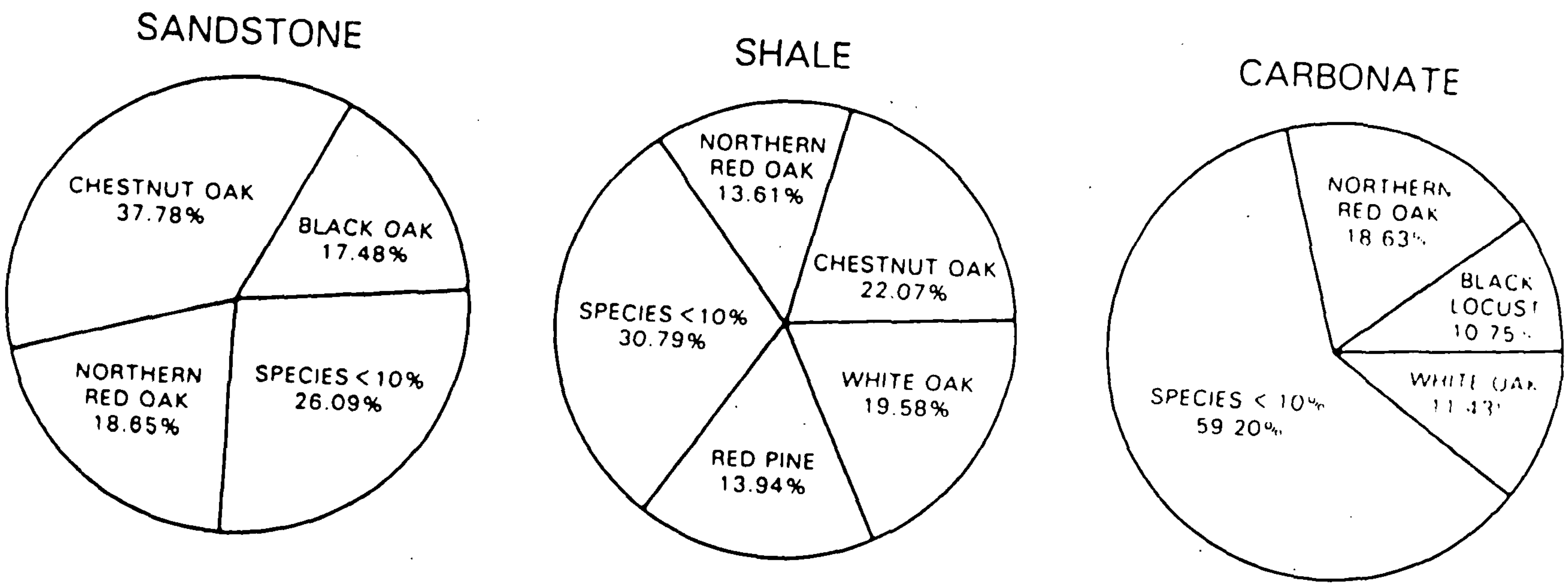

Figure 1. Pie charts showing the percent abundance of trees over 8" dbh (diameter breast height) at the average test site for each of the three lithologies. Species contributing to less than 10 percent of the total are not shown separately.

TMS BANDS	12 MAY 83	15 AUG 83	16 OCT 83	28 OCT 83
1 (0.45-0.52)		LS (SS SH)		SS SH
2 (0.52-0.60)				SS SH
3 (0.63-0.69)		SH (SS LS)		SS SH
4 (0.76-0.90)	SS (LS SH)			
5 (1.0-1.3)	SS (LS SH)		SS (LS SH)	SS SH
6 (1.55-1.75)				SS SH
7 (2.08-2.35)				SS SH
8 (10.4-12.5)		LS (SS SH)		

KEY:

SS (LS SH)	Sandstone separable from shale and limestone
SH (SS LS)	Shale separable from sandstone and limestone
LS (SS SH)	Limestone separable from sandstone and shale
SS SH	Sandstone separable from shale (data not acquired over Limestones)

Figure 2. A graphic representation of the results of the Tukey studentized range tests. When a circle representing a lithology does not overlap the other circles, that lithology is considered separable. Blank entries occur for combinations of date and TMS band in which no lithologies were separable.

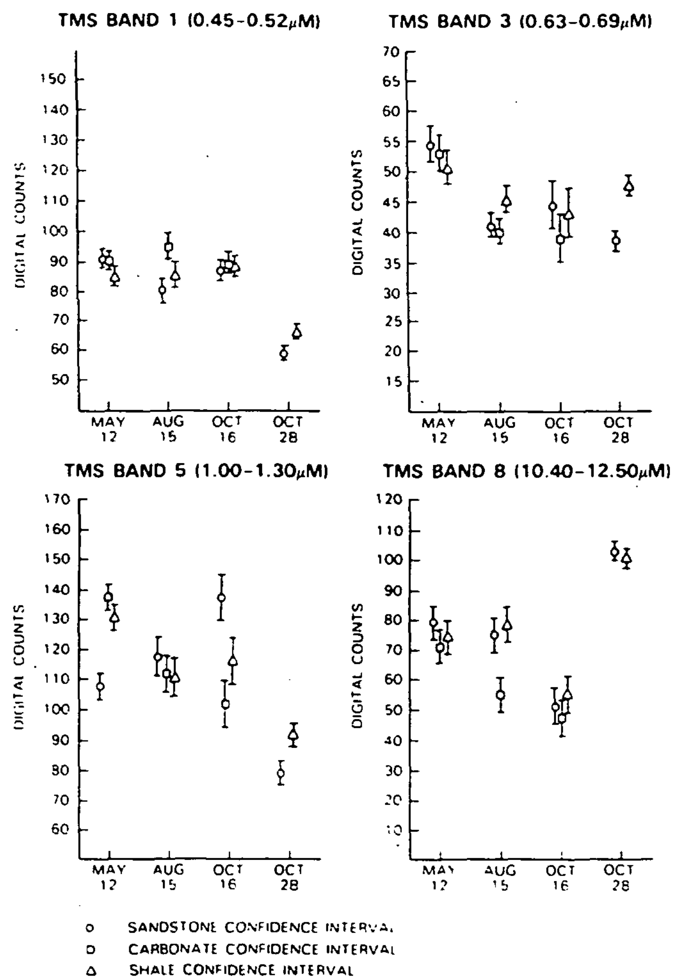

Figure 3. Data used to construct Figure 2. are plotted for the four most significant TMS bands. The error bars are based on the Tukey studentized range test.

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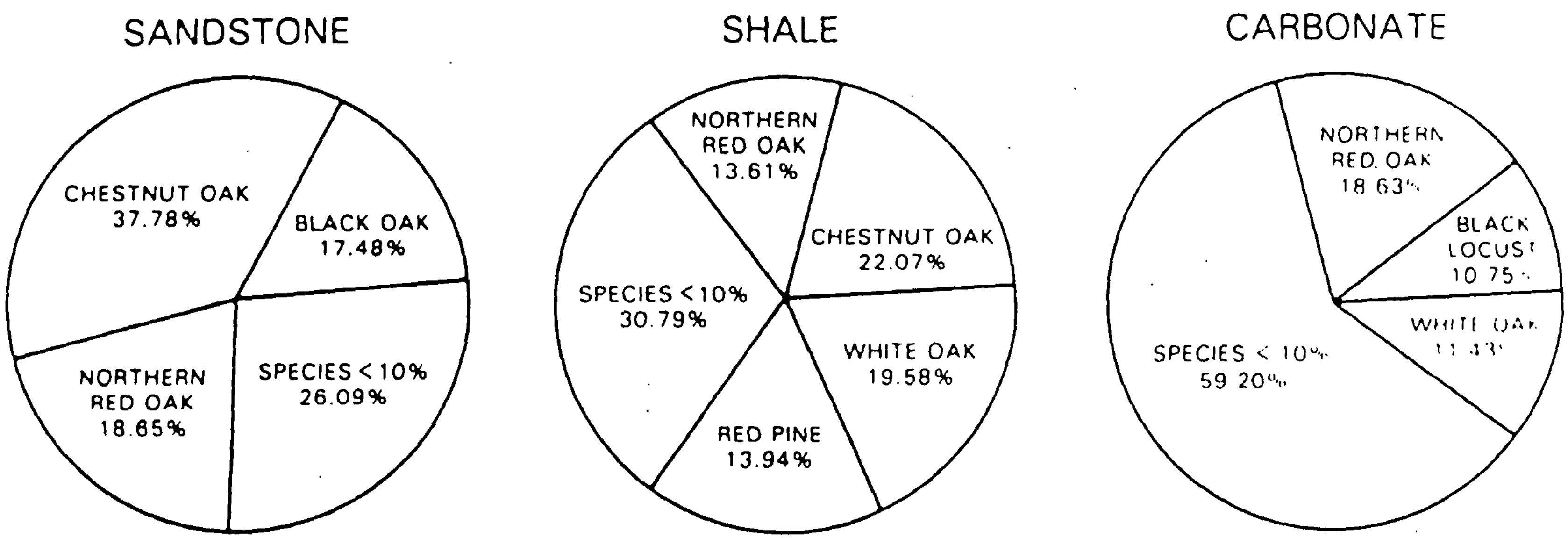

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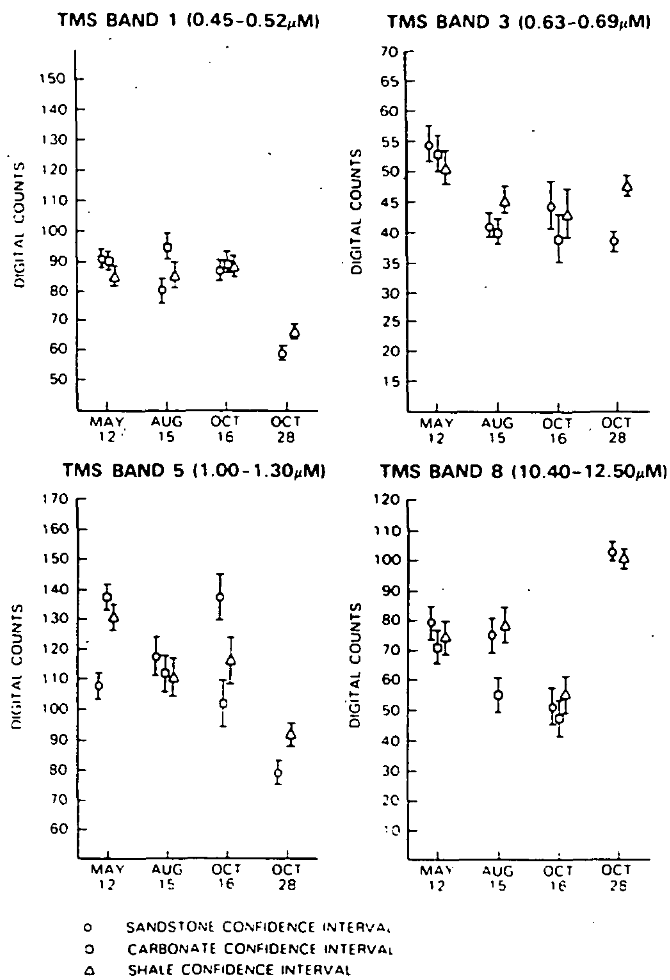

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